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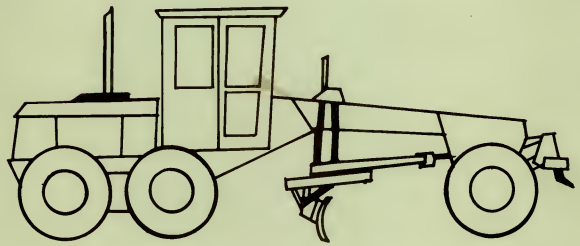

MOTOR GRADER OPERATIONS MANUAL

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MONTANA DEPARTMENT OF HIGHWAYS
MAINTENANCE & EQUIPMENT DIVISION

MOTOR GRADER
OPERATION AND MAINTENANCE MANUAL

GENERAL RESPONSIBILITY

This manual has been prepared for the field maintenance employees who are responsible for the operation and daily maintenance of the Department's motor graders. The information in this manual will be general in nature, in order to cover the several makes of graders owned by the Department.

You are not expected to be a trained mechanic, however, you are expected to know enough about the equipment you operate to recognize mechanical defects that might occur while you are operating Department equipment. Abuses to equipment occur from casual or uninformed operators. You are not asked to diagnose trouble when it arises, but to describe on Repair Orders the symptoms you have noticed or to know when the trouble is serious enough to shut down a piece of equipment.

PURPOSE

The purpose of this manual is to keep employees informed and aware, by so doing, providing better care and maintenance of equipment. Equipment that operates well allows you to do a job that you can take pride in.

The Motor Grader is one of the most important machines used in highway maintenance. The combination of the proper motor grader and good operator in many maintenance activities is of great value. Any maintenance operation should be directed toward restoring the road to its original condition and usefulness.

This program will be presented to all motor grader operators and potential operators. The motor grader is a complex machine, the operation of which requires good coordination, and to some extent a certain natural ability. These skills are acquired through hundreds of operating hours. It is hoped this program will improve the performance level of present operators, and provide a knowledge base on which potential operators can develop skills.

GENERAL INFORMATION

Something to always keep in mind is the basic design of any machine that you are operating. Remember that a Motor Grader is basically designed to level or smooth an area. It has a long wheel base so that it can span short depressions or humps. The blade is carried in the center so that the hump can be cut off, or a depression filled, by the action of the machine. Do not "fight" the controls; this will keep the machine from performing its job. The tandem wheels also allow the wheels to rise and fall without a severe effect on the frame of the machine.

The mold board is pulled by a draw bar which is fastened in the center of the front wheels. Remember that this is designed to take stress when it is pulled, and do not apply heavy pressure when the blade is lowered and you are operating in reverse. They also provide flotation and more uniform traction.

The moldboard is attached to the circle near the center. This makes it necessary to watch both ends of the blade when operating. The reason for this is that when you lift one end of the blade the other end will go down about 1/4 the distance. Also if the circle is not level, the blade setting will change if you change the angle of the blade. All these factors make it difficult to change blade settings while moving, so the fewer changes you make while moving, the better your work will be.

It is also important to operate the machine while sitting down so that you can feel movement in the machine. Learn to drive the machine in a straight line. This can best be done by watching ahead, lining up some object and driving toward it. Do most of your turning around in the borrow pits to avoid tearing the edge of the roadway with the tandems.

The terms normally used will be listed below:

1. Sharp blade - This refers to the angle of the blade in relation to a line at right angles to the machine, and will be an angle greater than 30 degrees from that line.

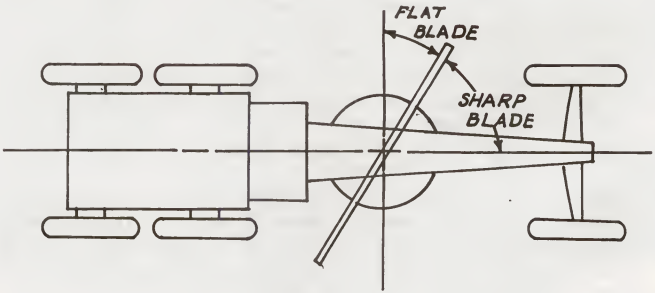

FIGURE 1.

2. Flat blade - This also refers to the blade angle and will be from the right angle line to 30 degrees from that line.

3. Pitch - This is the angle the cutting edge sits in relation to the road.

FIGURE 2.

4. Moldboard - What the blade is fastened to.
5. Cutting edges - Blade.
6. Ice blades - Serrated or saw tooth cutting edges.
7. Loose blade - This refers to setting the blade so that it touches surface, but the weight of the blade is supported by the machine.
8. Tight blade - This is setting the blade so that it has some down pressure on the surface.
9. Toe of the blade - The leading end of the blade.
10. Heel of the blade - The following end of the blade.
11. Articulating frames - Frames that pivot in the middle of the machine, for better traction and handling.

There are a lot of factors that influence blade settings. We will discuss these in the operating section of this manual as they pertain to the different operations being performed. Try to make as few changes as possible while moving and your work will come out better. Always remember that when you adjust one end of the blade the other end will also need adjustment. If you raise one end of the blade the other will go down about ½ of the distance. Your blade setting will also change if you side shift or turn the blade. All these factors are the reason why it is better to make as small, and as few changes as possible while moving. The machine will work to level the area if you set it right before starting a pass. Learn the "feel" of the controls on your machine so that you know how fast or slow they move the blade.

Operating speed is an important factor of the quality of work you produce. When ditching or blading, you must not try to hurry. A higher rate of speed could cause the grader to bounce and this would gouge the surface rather than smooth it. In extreme cases, the bouncing could cause you to lose control of the grader, producing a potential accident situation.

SAFETY FIRST - PROCEDURES

Prevention of accidents involving powered equipment is completely dependent on the person in charge of the equipment. No power-driven equipment, regardless of the type or the purpose for which it is used can be safer than the operator. The manufacturer can incorporate features to make the operators job safer and controls to make it easier. AVOIDANCE OF SITUATIONS WHICH MAY PRODUCE ACCIDENTS IS SOLELY UP TO THE PERSON AT THE CONTROLS, TO THEIR !FORETHOUGHT, JUDGMENT AND COORDINATION THRU (1) TRAINING AND (2) SUPERVISION. A careful operator is the greatest safety device there is. Stop accidents before they stop you.

Most graders have been designed to incorporate every safety device possible. With all these safety features, which have been incorporated in the design of the grader, there are still dangers. The operator must be extremely careful in the operation of a big machine such as this. In order to help prevent accidents the following safety rules should be observed at all time.

1. Become well acquainted with the piece of equipment, Operator's Manual, and Maintenance Manual. Know where all controls are located and what they operate.
2. All power equipment should be operated only by those who are responsible and delegated to do so.
3. Obey the decals which are located on the grader in areas of possible danger.
4. For safe operation observe proper maintenance and repair of all pivot points, hydraulic cylinders, hoses, snap rings and main attaching bolts prior to each day's operation.
5. Keep the operator's platform free of debris.
6. Be sure no one is under or around the machine before starting.
7. Always face machine when mounting and dismounting the grader.
8. Never jump from any machine.

9. Always maintain a firm grip on the hand holds while entering or leaving the machine, until you are in the seat or your feet are on the ground.
10. Clean your shoes of slippery materials to prevent slipping on steps, or off the clutch and brake pedals.
11. Keep windshield, windows and mirrors clean at all times.
12. Pull the keys before servicing or repairing grader.
13. Check all controls to be sure they are operating correctly before putting the machine to work.
14. Do not leave the machine unattended with the engine running.
15. When shutting down, always cool engine 3 to 5 minutes, lower all hydraulic equipment to the ground, and set parking brake before leaving the cab.
16. Never coast the machine with transmission in neutral or with clutch disengaged. Maintain a ground speed consistent with conditions.
17. Avoid operating too close to banks or overhangs.
18. Be sure to shut off the engine when refueling and do not smoke.
19. When you must work on hydraulic equipment when raised, be sure to block it securely with blocks which will not crush.
20. Never operate machine in closed shed or garage, open the doors.
21. Do not oil, grease, or adjust the machine when the engine is running.
22. Drive at speeds slow enough to insure safety and complete control, especially over rough terrain.
23. Increase the power gradually when pulling a heavy load or when driving out of a ditch or excavation.
24. Reduce speed when making a turn or applying brakes.
25. Keep brakes in proper adjustment. If you can't stop the machine, don't start it.
26. Never make repair or tighten hydraulic hoses or fittings when the system is under pressure, when the engine is running, or when cylinders are under a load.

27. Be careful removing radiator pressure cap when the radiator is hot.
28. Be extra careful when using cold weather starting fluid. Wait at least ten minutes before using starting fluid if you have attempted to start the engine with a manifold heater. Crank the engine 5 - 10 seconds before attempting to use manifold heater if you have used starting fluid first.
29. Always disconnect the battery ground strap before making adjustments on the engine, or electrical equipment and before welding on any part of the unit. This will prevent dangerous sparks which create a fire hazard and may cause harm or damage. Disconnecting the battery also prevents accidental operation of the starter.
30. Never permit persons other than the operator to ride on the grader.
31. Honk horn before moving grader.
32. Look behind grader, at all times, before backing up.
33. Always be sure of water, gas, sewage, electrical, and telephone line locations before you start any cut operations.
34. Always check overhead clearance, especially when transporting the unit. (Know your maximum height before transporting.)
35. When deadheading the grader, always have the blade toed to the off traffic side, and carried high.
36. To prevent highway accidents, use working signs, flags, flagmen and turn on yellow flashing cab lights whenever working on road surface. Display the "Slow Moving Vehicle" emblem.
37. Practice good housekeeping and clean out the cab at the end of each day. It is the responsibility of the operator to make an inspection of the grader each shift. The use of defective or unsafe equipment is forbidden.
38. Look for leaks and check fluid levels.
39. Use safety equipment provided with the machine for your protection.

Use common sense and good judgment.

EQUIPMENT INSPECTIONS

This section will be broken into four areas. Pre-starting procedures, staring procedures, end-trip inspection, and general operating information.

Pre-Start Procedures:

1. Grease the machine according to the operator's manual. As you grease the machine, check for loose, worn, or broken parts, hydraulic system leaks, worn hoses, and leaks under the machine.
2. Check engine oil level.
3. Check coolant level in the radiator.
4. Check belts for adjustment and wear.
5. Check hydraulic oil level if equipped with hydraulic controls.
6. Check power steering reservoir.
7. Check air cleaner and connections and dump the dust cup if the machine has one.
8. Check fuel level and drain water from the fuel tank.
9. Check transmission oil level on power shift transmission.
10. Lubricate the blade circle with graphite, diesel fuel, or a mixture of diesel fuel and motor oil, according to operator's manual recommendations.
11. Check tires and wheels.
12. Check starting motor oil level if your machine has one.
13. After starting, check gauges, clutch free play, steering, lights, and controls. Other checks indicated in the Operator's Manual may be necessary on certain types of machines but these points cover the general checks.
14. Drain the condensate from the air tanks.

Starting Procedures:

1. Make sure parking brake is set and place the transmission in neutral.
2. For machines equipped with electric starting, open throttle ¼ and use the starter.
3. Always depress the clutch to lighten the load on the starter.
4. Never operate the starter continuously for more than 30 seconds. Then wait 2 minutes before using the starter again.
5. After the motor starts, check all gauges to see if they are operating. After 3 or 4 minutes of idling set a fast idle to complete the warm-up.
6. Operate all controls to make sure they operate and to warm up hydraulic oil.

General shut down procedures and end trip checks:

1. Always cool out the engine for 3 to 5 minutes before shutting down.
2. Lower all hydraulic equipment to the ground and set the parking brake, before leaving the cab.
3. Make a walk-around check including:
   a. Loose, worn or broken parts.
   b. Hydraulic system hose and connection leaks.
   c. Any oil, grease, coolant, or fuel leaks.
4. After shutting down check fuel, oil, coolant levels, and blade wear so that needed items can be brought out in the morning.
5. Clean accumulations of dirt or mix that might hinder the proper functioning of any sliding surface, pivot point or lubrication fitting. Hardened mix be removed by pouring diesel fuel on the buildup area and allowing the mix to soften.
6. Always park the machine as near level as possible.

General Operating Information

Here are some general operating tips to help prolong machine life and reduce breakdowns. Keep dirt out of engine openings by wiping off dirt and grease before opening filler necks and dipstick tubes. Be sure that containers used to carry oil and fuel are kept clean. Do not pour cold water in a hot engine. It is always a good idea to fuel at the end of the shift, in order to prevent condensation in the tank. Always come to a complete stop before changing from a forward gear to a reverse gear. If you must leave the blade up at night, let it down on two short blocks. The machine can then be pulled as the blade will slide off of the blocks. Always use the decelerator, or throttle, to slow engine speed when shifting gears. Avoid unnecessary speed, particularly on rough ground. Do not spin the wheels as this is hard on the machine and tires and also makes the surface rough. Always engage the clutch slowly and do not jerk the machine.

Most motor graders will have six control levers in addition to the usual brake, clutch, transmission and fuel controls. For specific application to any given machine, refer to the operators manual, but generally a grader will have the following controls:

1. Blade Lift - These two levers are used to lower and raise the respective ends of the blade.
2. Scarifier - This control lowers and raises the scarifier. This may be used to rip up any kind of hard material. Be sure to drive in a straight line when the scarifier is in the ground to avoid breaking shanks.
3. Circle Reverse - This lever changes the angle of the blade in relation to the machine. This angle is very important to you as it will determine how far material is carried in the

moldboard. A "flat blade" will carry material quite a distance where a "sharp blade" will cause material to form a windrow at the heel of the blade.

4. Side Shift - By using this control you can achieve a greater reach on your blade, such as in ditching. It can be used to extend the reach of the mold board, as in shoulder widening, to push material over a bank and keep the machine on solid ground. Caution should be observed to keep the blade away from the tires.

5. Front Wheel Lean - This control will lean the wheels in either direction. This feature will make it much easier to turn the machine around. Always lean the wheels in the direction you want the machine to turn. They can also be leaned to help counter side-draft created by the pull of the blade when it is loaded. When you are working the machine on a slope lean them up slope to help hold the machine in a straight line. Leaning the front wheels will lower the blade slightly.

SECTION IV
OPERATIONS

When moving a heavy windrow or taking a heavy cut use the front wheel lean. This will help to counter side draft that can pull the front of the grader off line. Also a sharp blade will enable you to move more material to the side, while a flat blade will carry it along with the grader. Do not put too much load on the machine and spin the wheels; if necessary split the windrow and make more passes.

DITCHING: The first thing to do when cutting a ditch is to lay out a line, it can be marked with stakes so you can see them from the cab, this will help you to cut a straight line. When you are ready to start, angle the blade sharply and place the toe or leading edge of the blade behind the front wheel. Set the toe tight and raise the heel up (Figure 3). Drive the machine down the row of stakes taking a cut of 1" or 2" in depth. This is called a marker pass and will help to keep the ditch straight.

FIGURE 3.

FIGURE 4.

Do not make this cut so deep that you have trouble steering the motor grader. (DON'T GET GREEDY.) The next pass should be made with the same setting, but place the front wheel in the marker cut and put a load on the machine. Again, do not take more than the machine can handle. Put the motor grader in first gear and do not go too fast in case you hit a hidden rock. These settings will deliver the windrow under the grader and you will get better traction because you are not on loose material. The next pass, set the blade tight on both ends (Figure 4) to deliver the material outside of the wheels. Next set the machine straddling the windrow and carry the windrow away from the ditch bank. Always be sure to move the windrow before it becomes so large it is awkward to handle. If the ditch still needs to be deeper, repeat the steps as outlined except the marker pass. Normally when cleaning a ditch, the marker pass will not be necessary.

If a back slope is required, set one set of wheels in the ditch bottom and the other outside the ditch and put the heel down with

just enough angle to deliver the windrow outside of the wheels. Put the toe down enough to cut the slope desired. To clean the windrow out of the ditch without leaving anything in the bottom, set the blade so that the toe and the heel are inside of the wheels. It should be nearly parallel with the machine. Drive with one wheel in the bottom of the ditch and the other on the first slope. Have both ends set tight, but not cutting any deeper. This will move the material a short distance up the slope. You can then take a setting with a normal sharp blade and carry the material on up the slope to be disposed of, leaving the ditch bottom clean.

If a flat bottom ditch is desired, you can cut the flat bottom by taking the setting outlined above. The width can be set by the angle you put on the blade. The blade must also be leveled.

You may have trouble getting the blade between the wheels if it has extensions on it, but this setting prevents material from leaking around the end and leaving some in the ditch bottom.

BACK SLOPING: If a bank is too high and steep to get the machine on, the blade may be set out to one side of the machine (Figure 5). You can then drive along the bottom and cut the back slope in this manner. On most machines this adjustment must be made by manually adjusting the mold board out the side. This can be done by changing the location of the blade attachment to the blade circle. The blade lift arms can then be manually lengthened and by using the side shift control you can side shift to the extreme. One end of the blade can be raised and the other lowered to achieve the correct setting. The cut can then be adjusted by using the front wheel lean.

FIGURE 5

The final step in any ditch work is to check the ditch for drainage. This can be done with an eye level or simply by "eyeballing" it, but always make sure to check your work.

WIDENING SHOULDERS: This can be done in two ways. One way is to have trucks dumping material on the road surface. Repairing a washout on a steep shoulder is an example. Dump material in such a position that as you work, the material will be carried into the location where it is needed. Work the material out over the shoulder leaving it high. By working the material out slowly you will pack it into the hole as you work. Always pull some material in towards the road and save it for finishing work. After you have the hole packed full you can separate rocks and large chunks out of the windrow you saved by "high blading" it.

Roll these over the shoulder and use the small material to put a "finish" on the work.

The other method is to bring the material up on the road by cutting the back slope and ditch down. The material can be carried up on the road and finished as previously outlined.

Any time you want to separate large rock out of material in a windrow, set the blade 3" or 4" above the ground. This will leave the finer material and carry the large into a separate windrow.

BLADE MIXING SALT AND SAND: Spread the material out at least the width of the blade leaving a small windrow on each side. This will leave a smooth area several inches deep to spread the salt on. Roll the small windrows back over the top of the salt making a "sandwich" of material, salt and material. Then move to the outside and "pull" the material out of the "sandwich," in small windrows. This will use the full width of the blade to "roll" the material. The small windrow can then be pulled back to a central windrow. The salt and sand should then be mixed. If not, just repeat the process again.

BLADE MIXING (OIL & DRY MATERIAL): Aggregate should be dried and windrowed. When it is ready to mix, peel enough aggregate from the windrow to get a pad 2" to 3" thick, wide enough for the distributor, with a slope toward the large windrow. Also leave a small windrow on the outside of the material pulled out. The tanker or distributor can then drive on this material to spread the asphalt.

The motor grader can then follow the distributor peeling more aggregate from the windrow and cover the asphalt with a 2" or 3" lift. Successive lifts are placed in this manner until the required asphalt is layered in the material.

Set your blade pitch so that the material will roll (spiral) and mix thoroughly. If the material starts to "ball" put it in a large windrow and cut shallow lifts off the top. In this way you can cut through the "oil balls." If the aggregate has considerable fines blending can be difficult. Lower the blade so that it presses the layer of asphalt and aggregate, then back the motor grader over the mix. This will enhance aggregate coating as the asphalt migrates upward.

In general, when mixing always use caution not to cut too deep and get foreign material into the material being mixed. Always be sure to clean the area you are going to use, that is, cut

weeds and clear rocks, etc. off. Allow plenty of room to mix. Be careful not to lengthen your windrows out, and keep the ends tucked in. It will be much easier to mix if you keep the windrows even in depth.

For additional information on blade mixing and related topics, refer to Appendix A, Pages 62-71, in the MDOH Asphalt Pavement Maintenance Reference Manual.

BLADING APPROACHES: Many times there will be a high area in the center of the approach. Set the machine on the oil surface and drive into the approach cutting this high area down and carrying the material toward the right-of-way boundary. Stop and leave the material in a pile near the end of the area to be worked. This may require more than one pass if the material is hard.

When you have this completed, then turn the machine around and pick up the pile carrying it toward the oil surface. If additional material is needed, dump it on top of the pile you already have. Leave a windrow set up on the outside edge of the approach and drop extra material that may be in the blade in a pile on the oil surface. When setting up this windrow, use it to outline the approach. Turn the machine around again and set it up in the lane of traffic to turn into the approach. Pick up the pile and drive with front wheel on the outside edge of the windrow to carry the machine into the approach without falling in the depression. This will cause the blade to lay the material in with the correct curve and angle. Repeat this pass without running on the windrow but straddling it to complete the first half of the approach. Any excess material can then be used on the other side of the approach by using the same steps. When completing the job, allow excess material to be strung out on the back of the approach.

The key to this operation is driving off the oil surface on an angle as this puts the material down in the correct location.

BLADING AGGREGATE SURFACED ROADS: These roads need periodic maintenance to provide good ride and drainage characteristics. Set up your initial pass to bring aggregate to the center of the road. Set a flat, loose blade with the toe on the shoulder. This setting will strike off high spots and carry the spoil to deposit in depressions. Any additional material will windrow in the center of the roadway. This prevents the loss of aggregate in the borrow. Close attention must be given to your blade to prevent causing problems. Always use care to maintain or re-establish the proper crown or superelevation.

Work in the direction of travel until you reach a safe turnaround point, then work back to your starting point. Feather your centerline windrow to the shoulder on the second pass in either direction. Extend the blade over the shoulder to keep from building a dam on the shoulder that would disrupt drainage characteristics (Figure 6). Don't work out of the effective distance of your signing. Move them along as you progress along the road.

FIGURE 6

There are a few cautions that warrant constant attention.

1. Leaning the front wheels will lower the blade and establish a heavier cut.
2. Raising one end of the blade lowers the other end about ¼ as much as that end was raised.
3. Reversing the circle might be necessary to position the heel of the blade to deposit any spoil on the high side of a

super. This keeps from filling the low side ditch with spoil.

SNOW PACK & ICE: Cutting snow pack and ice with a motor grader has special hazards that require extreme caution on the part of the operator. Some simple equipment changes can improve the operator's odds in these situations. The first and simplest is to chain up; second, if the machine is not all-wheel drive, is to reverse the front wheels so the tread is opposite to that on the drive wheels. Always drive straight and do not use so much down pressure that the front wheels are raised to a point that steering is ineffective. Be careful of iron in the street, manhole covers, water shut-offs, and expansion joints. These objects can catch the blade and cause sudden, abrupt changes of direction for the front end of the grader.

PATCHING: This will be discussed in several subsections. Different types of patches will require slightly different methods. The first area to discuss is general steps. Always keep in mind the major objectives are to level the area, have a good riding surface, and to leave a good appearance. To accomplish this, you must have straight shoulder lines and neat tapered ends, to provide a smooth transition to the original surface. Plan the locations for the ends of patches. Adjust the length to avoid ending in a depression.

The first step in any patch is to cut off high spots and clean any old cracked or broken oil mat out of the hole. It may be necessary to sweep some dust or dirt off to achieve a good bond. The surface must be clean in order for the asphalt tack coat to stick to the mat. If the shoulder is higher than the mat, cut this down level with the mat so water can drain away. Take all material to be wasted off in the borrow pit and spread it out so that it is not a hazard to mowers. This also leaves a good appearance.

Be sure to extend the patch a short distance on each end of the patch so you can taper the ends. Try to stop and start the patch on level road, if possible. Spread the tack coat on the area to be repaired. Dump the pre-mix on the tack coat only and this will help you to have neat ends. Try to avoid getting pre-mix starting at the end you intend to work from and stop before reaching the other end.

On half-road patches take the pre-mix to the center of the road first. Operate with a moderately flat, loose blade for the first pass. The flat blade will tend to even out pre-mix which is not dumped evenly. The loose setting will keep you from cutting into the old mat and getting chunks in the material. When you reach the end of the tack, stop and lift the blade. At this time you can use the back blade process. Drive forward and line the machine up so that you straddle the windrow. Go to a sharp, tight blade. When backing up be sure to back in a straight line. The back of the blade will carry material back to the starting end of the patch and will also help to break up any chunks in the premix. Windrow position is very important. Be sure you do not put the material out too far towards the shoulder. It should be placed in the approximate center of the area on a two lane road. Again, position the machine to straddle the windrow. This pass is the second most important pass you will make. Have the outside edge of the windrow falling where you want the edge of the patch to be. It should be sitting on the edge of the existing mat. Be sure to drive straight during this pass. Before making this pass be sure to have the windrow even in size, so pre-mix will fall in a straight line coming out of the blade. The exception to this might be if there is a deep hole in the center. You would need more material there, but allow extra room during this area to hold a straight line on the outside of the windrow. When you reach the end of the patch stop. Raise the blade leaving material in one pile on the end of the tack coat. Turn the machine around and approach the patch from the opposite direction. Always stop close to the end of the patch and on level

road. Set the toe of the blade directly behind the outside front wheel with a sharp angle. Be careful that the premix coming out of the blade will not fall under the rear wheels. Set the blade down using a loose blade. When you drive forward put the outside front wheel slightly up on the side of the windrow. The blade will pick up the pile and as you drive up on the windrow, this will raise the blade slightly making the taper for that end. Be sure to drive the same height up on the windrow all the way across the patch. This will leave a level area even though it was not level to start with. When you reach the other end, gradually edge back down onto the shoulder edge and this will lower the blade putting the taper on this end. When the end of the tack coat is reached, cut the wheels sharply in to the road, and again stop and leave material in a pile. The reason for this is so the front wheels can go over the pile dropping the blade back down on the road to pick up all material to avoid adjustments. By running the tire on the edge of the windrow, it will carry the machine level across holes and high spots and also pack the edge of the windrow so material does not leak out of the blade ruining the straightness of the shoulder line. It also gives you a level pass to guide from for the rest of the patch. THIS IS THE MOST IMPORTANT PASS OF THE PATCH.

When you back up you can follow the tire tracks back packing the edge line again. This is the only time you will ever run on a windrow, out on the mat it will make ridges.

The next pass is to carry material on out to the center of the road. Do not use as sharp a blade setting on this pass so that the windrow will again even out. Position the machine to straddle the windrow and carry pre-mix to the center of the road. Stop on road level and tilt the front wheels toward the tow of the blade, set the blade flat and loose. As you drive forward, watch the blade and when it has material in it, begin to straighten the front wheels. This will raise the blade on both ends following the taper started by the first laydown pass. When you reach the

other end, tilt the wheels back down to run in that taper and cut the front wheels to the shoulder and straddle the pile. On machines that do not have leaning front wheels, the toe of the blade must be raised as you drive, and then the heel raised, to run the taper in. All other steps will be the same. Again stop and raise the blade. Now turn the machine around and approach the patch stopping on level road. Again use the wheel tilt method and set the blade at a sharp angle. You should have laid approximately two-thirds of the amount of pre-mix that was dumped on the patch. Use the rest of the material to put a finish on the surface of the patch. Do not tilt the wheels as far down now so that the blade will be close to surface of the patch. By using a sharp and tighter blade, any chunks will be carried in the blade and drag marks will be eliminated. Lay about ½ of the remaining material in this pass. The material should run out just before reaching the end of the patch and there will be no pile left. Back up and repeat the same pass straddling the windrow with the heel just even with the edge of your patch. Let a very small amount of material roll off the edge along with the chunks. This will assure you that all drag marks will be filled and the surface will be even clear across the patch. By leaving the chunks along the edge you can roll them down and leave a good appearance to the patch.

On tapered sections transitioning from one width roadway to another, or where you wish to re-establish a straight shoulder line, sometimes it is easier to work from the shoulder than the centerline. Establish a windrow from the dump spread approximately two feet from the shoulder, uniformity or exact distance is not crucial at this point. Position the grader with the outside wheels right on the shoulder with a tight blade, sharp enough to cast the windrow beyond the inside wheels (Figure 7). This pass should run straight down the shoulder establishing the windrow at a uniform distance from the shoulder.

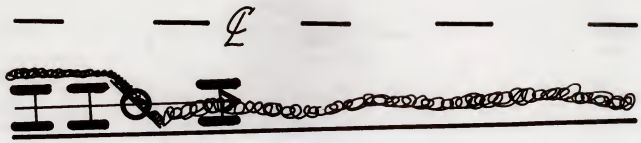

FIGURE 7.

Turn around and without changing the blade setting, drive back down the shoulder line again (Figure 8). This pass puts the windrow in line with the shoulder, and in position for the spread pass.

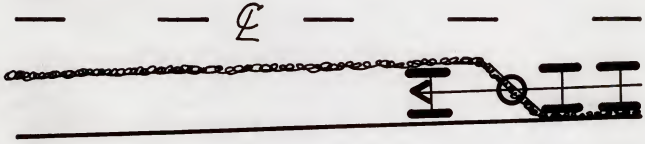

FIGURE 8.

You may not have the material run out just perfect and you will have to take the windrow back to the center and then complete the patch. If this is necessary, do not carry the windrow clear to the edge. Leave room to put a wheel between the windrow and the edge and carry it back. Never come clear out to the edge until you are ready to finish the patch. If you have just a small pile at the end of the patch, you can blend this back over the patch but do not string it out down the road. If there is a lot of material left, shoot some more tack coat and put the pre-mix on this. Do not blade if off into the ditch and waste it. One way to tell if the blade is the right height above the area already laid, is to watch just behind the toe of the blade. It should just touch and roll a rock or two now and then as you move along. Always make as few passes as possible so the material will not

separate. Too much working will separate the rocks and fines and the rocks will whip off of the surface. Remember that blade pitch is important. You want to force the material under the blade so that the surface will be tighter, but not enough pressure to cause the patch to tear. Be sure that the toe of the blade is set correctly. If it is too loose, a ridge will be formed where the blade picks up the windrow.

These are the basic steps in laying any patch and if they are followed you will get good patches. Full road patches may be accomplished by shooting tack coat on one side and windrowing the dumped material to the center. The other side can then be tacked and material carried on across. By the time you reach the other shoulder the material should be in position to set up your shoulder line. Begin laying material as outlined. When you reach the center tight blade material across and set up that shoulder line. Again lay material to the center of the road. The remaining pre-mix can then be used to finish either side depending on where it is needed using the steps outlined for finish work. These steps will give you a "tight blade" and then a lift laid on top. A half-sole is just a long patch and the same steps are followed. One thing different is that you will probably have to lay it in sections. When choosing a point to turn around be sure to pick a spot where you can turn easily and off of the road surface. Do not turn the machine around on fresh laid oil mix as the tandems will tear it. Blend the ends back over the first section to eliminate all traces of an ending.

Remember that a flat blade will tend to level more than a sharp blade. The additional reach will give this effect but it will also tend to tear the patch. The amount of angle you can use will depend on the amount of heat and moisture in the pre-mix, and the type of material used to produce the pre-mix. For example, on a hot afternoon you could use a much flatter blade than on a cloudy morning. Most of your lay-down work should be done in low gear with the throttle open. This will give you

"live" controls without excessive ground speed. Too much ground speed will cause a bounce in the machine, causing "wash boards" in the patch. If you have to dry the material, roll the entire windrow back and forth a few times, or spread it out and then pick it up. Be sure to pick it all up to avoid separation.

DIPS: A short deep dip may be laid using a short cut. Extend the tack coat about a truck length on each side of the dip. Tin cans or any type of marker can be set on the shoulder to mark where the dip begins and ends. The pre-mix may be dumped in one pile. Drive over the pile taking as much material as you can and dropping it in the dip. Back up and set the blade with a tight and sharp angle to the shoulder. Pick up all the rest of the material and set up the shoulder line. Back up and begin to lay the patch. The material you put in the hole will support one front wheel and the windrow will support the other. When you come to the markers, ease the front wheel higher on the windrow and this will lay more material in the dip. Ease down at the other marker to run the end taper. Finish the patch using the same methods as above.

The advantage is that you will not have to turn the machine around so much. Speed with a motor grader is made by making fewer passes, not with a high ground speed.

ROAD CENTER PATCHES: On patches where you do not have to form a shoulder line such as a hole in the center of the road, just spread the material to one edge of the tack with a tight blade. Then straddle the windrow and leave the toe tight to the road. As you drive forward raise the heel slightly to begin laying material. Set both edges in this manner.

If patches are long and you have to wait on trucks, lay the loads back toward the work you have finished and blend the ends back over the finished work being careful not to leave any bumps.

BRIDGE ENDS: When patching a bridge end set your shoulder windrow up so that it is very small as you come to the bridge. When you drive this windrow and approach the bridge you will be able to run up on top of the small part and avoid the bridge rail. Always lay towards the bridge on the shoulder cuts. Then follow the normal steps for the rest of the patch. Be sure to allow enough lead distance so you do not raise the cars too suddenly. Run the taper from the end of the patch up to the bridge and make the raise gradual over the entire length of the patch.

CATTLEGUARDS: If you have to patch a cattle guard, this patch will require caution so as not to lose the material down in the cattleguard. To avoid this, come up to the cattleguard watching the toe of the blade. When the material in front of the blade is close to the rails use the circle reverse to flatten the blade so material will be pushed up close all along the length of the blade. Raise the blade and drive far enough forward to position the blade on the other side of the pile. Lower the blade and back up. This will carry the material back away from the cattleguard and it can be blended back over the patch. Handle both sides of the road in the same fashion.

SHARP CURVES: When patching on sharp curves ride higher on the windrow to allow for the tandems dropping down on the edge of the material as you turn.

ROLLING: The last step in laying a patch is to densify it by rolling. This is very important as it will prevent loss of surface material due to "kick off" from high speed traffic. It is best to use a roller, but if you do not have one, roll it down using the trucks to reduce the voids and raveling, thus increasing durability. Always roll the shoulder first and work the material toward the center of the road. If it has a steel drum, allow 4" - 6" to hang over the shoulder but avoid letting the roller drum "tilt" back and forth as this will spoil your

shoulder line. The rolling operation is very important to your work. Avoid turning the roller on the "fresh" patch. Normally roll the patch after it is completed. An exception would be a very deep hole. A small hole can be rolled with the grader wheel but on a large one can use the roller. Lay the material to the center and then let the roller roll the material on this lift. Then another lift can be laid over this. If you can avoid having to roll in the middle of the patch it is best because the layers that are laid will bond together better. However, it is better to roll deep lifts individually to avoid having the material settle too much as traffic packs it. If the material is more than 0.2 feet, lay it in equal lifts. The reason why it is best to roll small areas with the motor grader wheels, is so that when the patch has stopped settling, it will be level. Do not over roll a patch as you can force the material out of the hole. About two trips across the patch will usually set it in place. This may vary depending on the weight and type of roller.

MATERIALS: The type of material used will affect your procedures to a great degree. The type normally used is mixed with a "cut back" asphalt. Mostly an MC asphalt is used. This stands for medium cure and this type can be left in the stockpile for quite awhile. Lighter grades of MC are used when cool weather is encountered. Heavier asphalts should not be used when materials are to be stockpiled for long periods. A cut back oil is simply one that has an agent added to make it workable at a low temperature. Aggregates with large amounts of fines will be hard to lay. This material is a "fluffy" or "sticky" type of pre-mix that tends to drag along the road without going under the blade. This must be laid in deep lifts and rolled after every pass. Hot plant mix using asphalt cement must be worked at very high temperatures. It is used mostly with lay-down machine but sometimes you may be called on to lay it with the motor grader. It becomes unworkable very rapidly, so speed is very important. It can be spread from the truck very evenly so your first pass should set up the shoulder line. Lay it back one pass and then

dress to the outside. This will complete laying that load in three passes. Just dump one or two loads at a time and lay each load in layers. If it is a wide road, lay it in strips and then dump a small amount more on the center lift and dress it right to the edge to complete your finished surface. Be sure to roll each lift as you put them down, as you will be unable to get any compaction if it cools too much. If the lifts are too deep you will have to wait to put the roller on it, or the hot material will push out of the hole. This is why it is important to lay it in lifts. You will only have about three passes or it will become unworkable. You might get four trips on a hot afternoon, but better results will be obtained with only three.

Compaction is a critical element in asphalt pavement maintenance. Time and temperature can become important considerations because as the mix cools it becomes more difficult to work. Compaction usually involves three phases.

Phase 1. "Compression" or "Breakdown" passes are the first passes aimed at reducing the voids in the mix and expelling as much air as possible.

Phase 2. "Orientation" rolling is the intermediate process that positions the particles and densify the material. A further purpose of this intermediate compaction is to stabilize the mass to minimize distortion by traffic.
Phase 3. "Finish" rolling is to establish the final surface and remove any marks from prior rolling.

For additional information on compaction, refer to Appendix B, Pages 72-80, in the Department's Asphalt Pavement Maintenance Reference Manual.

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